



AIR FORCE CYBERWORX REPORT 17-002

Air Force Smart Bases

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Introduction to AF CyberWorx

CyberWorx is a dynamic organization partnering Airmen, industry, and academia to reimagine how technology might enrich and protect our nation, businesses, and lives. As a human-centric design center, we seek out unique ways to connect Air Force warfighters with current and future technology in meaningful ways. We look to transfer, license, and share promising prototypes, solutions, and knowledge with our partners to create value for both the warfighter and the economy as this is the best way toward operational advantage.

Design Thinking @AFCyberWorx

Design thinking is a common sense, human-centric problem solving method embraced by innovation leaders in industry, but often overlooked in the government sector. The CyberWorx design thinking process is a transdisciplinary method that breaks down silos of standard organizational structures. Organizations naturally form structures based on specializations to facilitate deep expertise, but these structures often impede creativity, collaboration, and knowledge sharing vital to innovation. CyberWorx deliberately reaches across specialties to bring diverse perspectives to a problem in a non-threatening environment. This evokes ideas that would otherwise be missed or stifled. The transdisciplinary design approach teases out meaningful solutions that are intuitive and desirable to Airmen.

Air Force CyberWorx offers facilitated design thinking sessions that bring stakeholders, industry and academic experts together to develop solutions to hard problems. These sessions are tailored to best meet AF needs with differing lengths based on time sensitivity and CyberWorx capacity. One method, which maximizes solution agility and the educational benefit to warfighters and industry partners, is to offer a design sprint where the week-long design project answers a challenge being worked for AF stakeholders. The goal of such a design sprint is to develop low fidelity prototypes that clearly convey the desired

Airman experience and the technical and policy developments needed to bring that experience to fruition. These projects help refine the requirement by seeking the right problem to solve and finding meaningful, forward-looking solutions by exploring a wide range of possible answers to the design problem.

The CyberWorx design thinking approach deliberately breaks through the military's hierarchical and mission silos to find hard-hitting answers.

Background: Complexity of Acquisition and Integration

Integrating the Internet of Things (IoT) into the workplace is as simple or as complicated as we make it. Single devices find their way into facilities to meet minor functional needs such as turning lights on when someone enters a room or monitoring energy usage by a squadron or department. Technical and policy complexity is increased when wearable devices are added to the mix to grant quick and seamless access through security gates, automatically log into computers, reduce insider cyber threats to information or critical infrastructure, or monitor an Airman's physical fitness, diet or vital signs as a way of improving the health of the force. The capacity and uses for smart technologies is seemingly endless and their uses have the potential to improve the quality of each Airman's life, as well as provide the Air Force with greater management tools, cost savings, and increased productivity for conducting its core missions.

While we'd all like to wake up one morning and have the ease of smart technology fully integrated into life on an Air Force Base, the task faces challenges. Technology has evolved to enable many uses with tiny devices, but fear and acquisition complexities have kept the Air Force from making significant strides toward smarter bases. Add to that the challenge of integrating a system with existing devices from a variety of vendors, antiquated technology and multiple platforms across functionally-aligned stove-pipes and the task becomes daunting.

Air Force CyberWorx was tasked with gathering a team of government and industry partners to conduct a design sprint to lay out a unified path forward for the AF to enable better experimentation and unity of efforts moving toward the future. Then to design an information and data architecture to enable many use cases for further mission experimentation and acquisition strategy development.

A key feature of the future of smart cities (or, in our case, smart bases) is that citizen engagement with one another and with their government services are improved, enabling citizens to accomplish their goals and city departments (or "functionals" in the case of the Air Force) to better serve those citizen-goals while gaining efficiencies, security, cost savings and other department-centric goals. The great promise of IoT is that both citizen and the city (or Airmen and their bases) are improved through the integration.

Problem Statement

How might we best leverage IoT and IT commercial technologies to make AFBs better places to work, more energy efficient, more secure and engender a culture of continuous-learning? It's no surprise that leaders perceive the Air Force lagging far behind industry and cities in the adoption of smart technologies: according to a 2017 Gartner report, "smart" technologies are nearly at the top of the "hype cycle," meaning there is much buzz about the technologies and promises, but the hard works of fully integrating the technologies has not been completed and

remains ahead. Despite their potential to make Airmen's day-to-day life experiences better while increasing the effectiveness of squadron and base operations, smart technologies on Air Force Bases seem like a dream for the far distant future.

For now, Airmen seem trapped in industrial age processes that lag far behind the technology integration in their personal lives. Often this gap leads to Airmen spending hours each month, sitting in unnecessary lines at gates and clinics; losing time searching for information on base services and events, and logging onto their computers and then into an array of disparate applications with no consistent look and feel as they struggle to efficiently do their jobs.

Base utility service providers rely on manual notification of HVAC and plumbing issues at facilities, often not discovering problems until well after they've grown into bigger and more complicated issues. Family members and visitors discover they have no WIFI connectivity in many areas where the only internet access is provided by a closed .mil network. All of these issues lead to two things: unsatisfied Airmen and inefficient mission execution.

CyberWorx brought together military and industry partners to investigate ways in which we might improve the efficacy of 1) mobility, 2) energy, 3) automation, 4) learning and sharing, and 5) cybersecurity on Air Force installations.

Participants

The design sprint brought in over 30 participants from across the military and industry. Decision makers, service providers, and base users gathered together to look at the problem space from their varied perspectives. This cognitive diversity provided unique value, breaking down traditional military hierarchical barriers to allow all viewpoints to be heard and considered. Furthermore, key insights from industry partners helped shape the team's design effort, expanding the "realm of the possible" beyond the current Air Force status quo.

Theme Discovery

The early stages of a design project and the design thinking methodology call for diverging on the initial problem statement to open the aperture of possibilities. To facilitate creative solutions, teams were encouraged to brainstorm hundreds of ideas, disregarding for a moment, current policies, available vendor solutions, and security constraints.



Figure 1: Participants from ten different companies made up approximately 40% of the #AFSmartBases Design Sprint.

Once all the ideas were on display, teams looked for themes and began identifying possible use cases. Furthermore, they began to reconsider constraints as they voted on the most viable and feasible areas to concentrate their efforts. The team decided that smart technologies would garner the biggest impact in the following areas:

- Push valuable info to base users
- Minimize waiting times
- Provide ubiquitous mobile coverage

The design sprint participants then spent time developing personas (users) who would have existing stories within the #AFSmartBases framework and whose stories could be improved through proposed advances. Crafting these stories and working to design better ones exposed additional themes, potential solutions, and constraints. By the end of the week, the team had narrowed the uses for smart technology solutions to six use cases (captured in the script that follows).

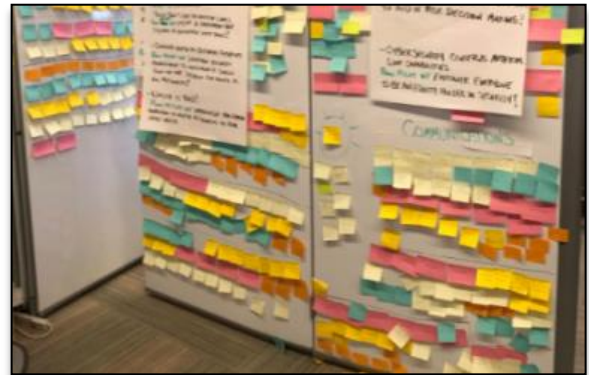


Figure 2: Designers ideate 100's if not 1000's of ways IoT and smart base technologies may improve the lives of Airmen.

The Next Steps

After the sprint, CyberWorx contracted with the IT consulting firm, Gartner, to develop a generic data and information architecture that would support these use cases (and to jump-start the myriad of additional use cases such a “Smart Base” will enable Airmen to innovate in the near future). The Gartner consultants participated and observed during the sprint so they had a clear understanding of the design teams’ intents and how to support the outcomes described in the sprint.

Gartner support was critical for the follow-on to the sprint so that the Air Force (and potentially other DoD organizations) can move forward on plans for implementing a vendor-agnostic data architecture to allow soldiers, sailors, airmen and marines to make the best use of IoT and mobility for generating combat power while maintaining cybersecurity and accruing the benefits of technology in their lives.

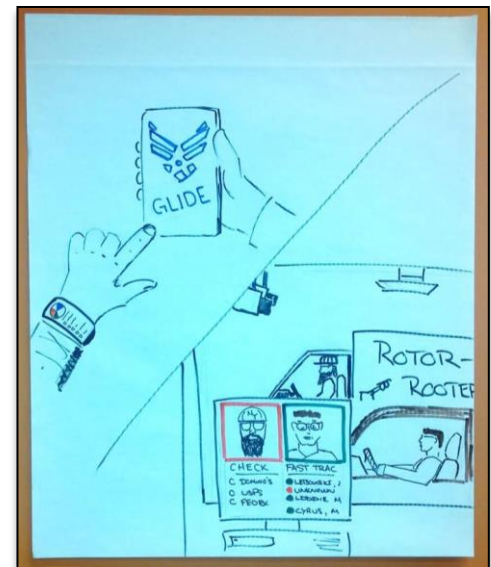
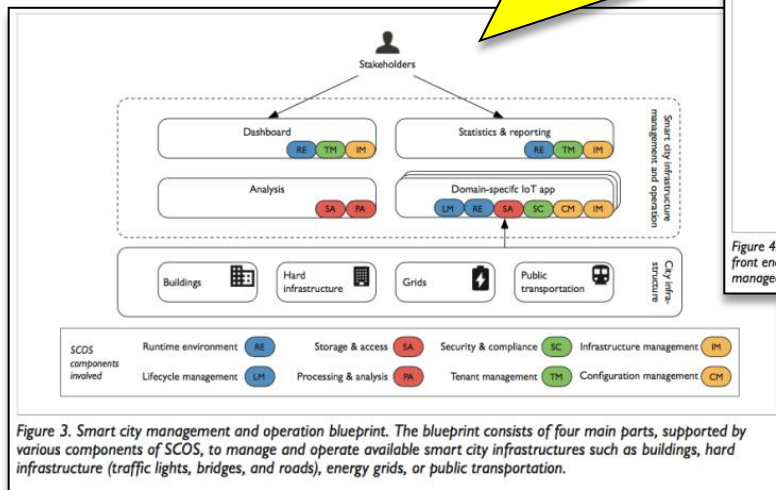


Figure 3: A conceptual AF mobile application pushes desired and local data to Airmen on demand.

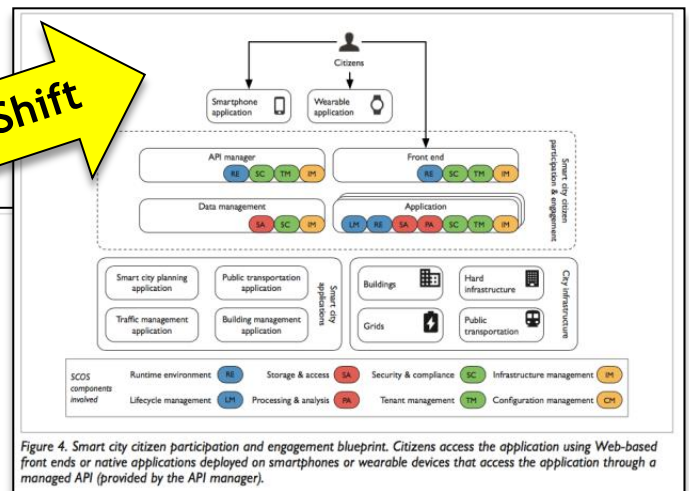
The Gartner “hype cycle” for smart cities shows that the DoD is not as far behind commercial industry (and local governments) as some fear. Although there are pockets of accelerated integration of smart/IoT technologies in some cities, many implementations still fall within “stove pipes” of functional areas in cities and commercial organizations. In other words, the use cases being implemented are supporting certain areas of government (transportation, for example) more than others (e.g. recreation and taxation) and the citizen use cases (making best use of data and IoT across areas of government) are not as well developed.

J. M. Schleicher and his colleagues (2016) write about this need for both functional and citizen (or in our case “Airmen”) application architectures in volume 20, issue 6, of the *IEEE Internet Computing* journal, two figures from which we have borrowed, below, to show the framing difference and the need for an architecture that accounts for Airmen use cases first because, otherwise, functional stove pipes will not allow for the types of data sharing and IoT innovation that unlock mission capabilities for Airmen. Both use cases are important (and can be integrated), but the functionals must continue to remind themselves, and data architecture be designed to support, the citizen views of the smart city.

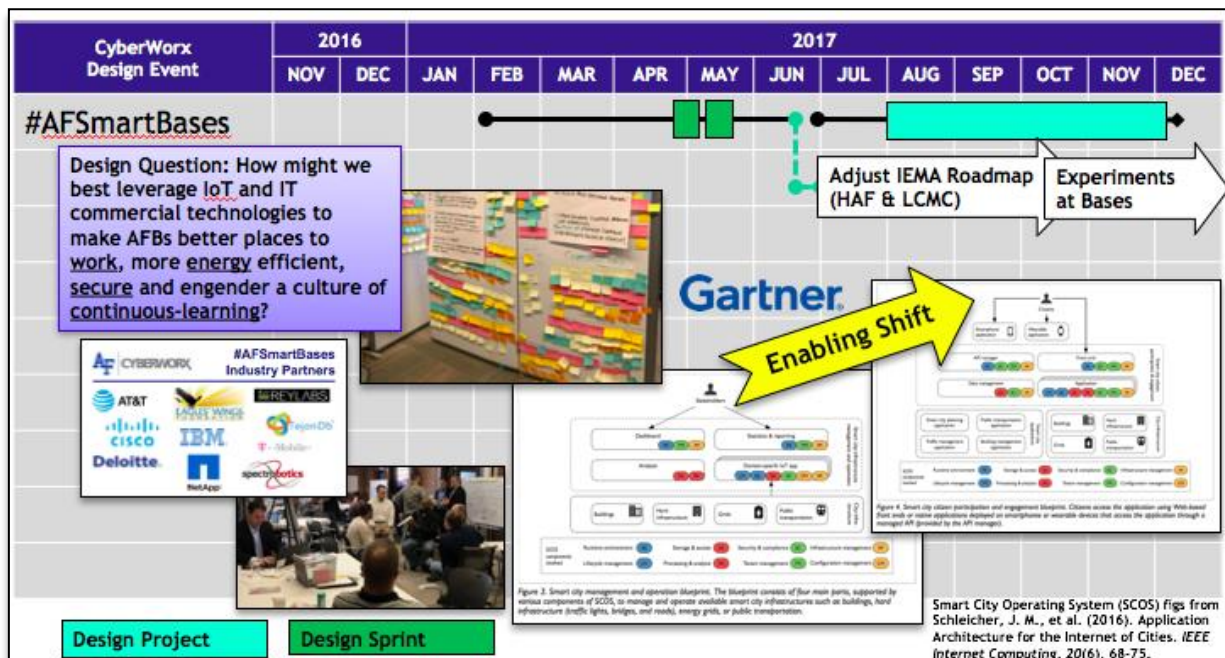
The contract under which CyberWorx had Gartner design an architecture resulted in a proprietary architectural report that is not publically releasable, but is what the government will use (1) to move forward on a centralized acquisition strategy (through the Info Environment Mission Area, IEMA, Roadmap, maintained by SAF/A6S in coordination with the AF Life Cycle Management Center, AFLCMC and AF Network Integration Center, AFNIC) and (2) to enable bases (and organizations like CyberWorx) to start experimentations and moving forward in a direction aligned with the desired end-state from a data architectural standpoint. Experimentation is important for discovering where the architecture needs further refinement or may not support the additional use cases that our brilliant Airmen will invent.



Enabling Shift



Smart City Operating System (SCOS) figs from Schleicher, J. M., et al. (2016). Application Architecture for the Internet of Cities. *IEEE Internet Computing*, 20(6), 68-75.



The Airman Story

This story follows TSgt Big Lebowski through a typical day on Eagle Air Force Base, highlighting the many ways smart technology impacts his life and work.

In a neighborhood just outside Eagle Air Force Base, external lights begin to turn off automatically as the sun comes up. Inside one of the houses on falcon court, TSgt Big Lebowski turns off the alarm on his smart phone and immediately clicks into AFGLIDE, the Air Force Guided Life Information Enhancer. Quickly looking over his schedule, he sees he has a medical appointment, the weather for the week, a notice that one of his troops has been told to have a urinalysis this morning, and the lunch menu at the dining facility which excites him because chili mac is today's lunch. He puts on his smart watch and continues his morning routine while the voice coming from his wrist reads him this morning's tips and tricks that maintenance techs get every morning now, which he has discovered has really helped him stay in sync with peers across the globe.

As TSgt Lebowski drives into work, he recalls how he used to have to leave his house so much earlier to wait in line to get on base. With AFGLIDE and its profile, based on biometrics, he is able to just slow down while his smart watch is scanned, his car is recognized by the security systems at the gate and facial recognition lets the security forces Airman know everything checks out and he should be waved in. Happy he is on his way, he glances at the others waiting in the vehicle inspection line. As TSgt Lebowski passes through the gate, SSgt Gladwine watches a dashboard at the Intelligent Operations Center (IOC), tick to 75% on the real-time accountability display.

TSgt Lebowski's first stop of the day is the base fitness center. He jumps on the treadmill and his run time is already programmed, based on his AFGLIDE profile that has taken into account the food he has been eating, his vitals, and his overall fitness goal for the month. Finished with his run, he quickly asks his smart watch where he now ranks in the base fitness competition and smirks when he realizes he just passed Luci, the gym fitness trainer, on the leaderboard.

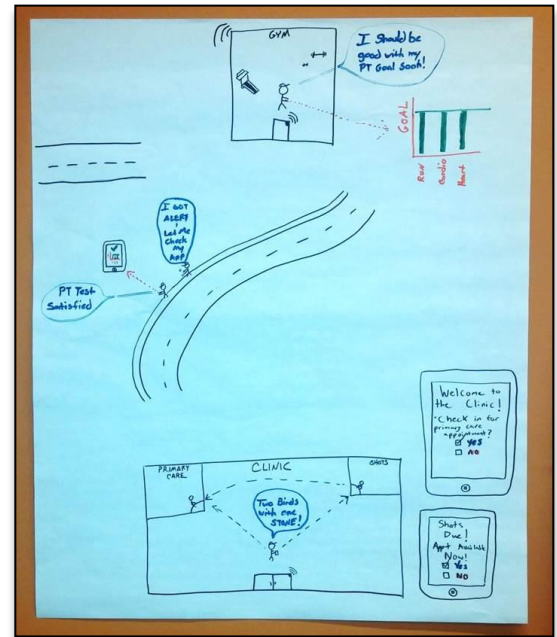


Figure 4: Smart wearables provide key insights into airmen fitness activities reducing the number of PT tests administered while ensuring a fitter fighting force.

It's only about half a mile from the gym to the base clinic and, still happy about beating Luci, he decides to walk to his appointment. Just a couple of minutes into his walk, AFGLIDE, which has been monitoring his daily steps, reaches the threshold set for his required fitness score and notifies TSgt Lebowski that his PT test requirement has been satisfied.

TSgt Lebowski is having a great day! He walks into the clinic with a spring in his step. Pulling out his smart phone, he sees that it knows he is already in the clinic and prompts him to check in. Since he is a bit early, a notification comes through telling him he is due for a flu shot and that there is time right now in the immunizations clinic.

On Eagle AFB, the perimeter is patrolled by security drones. There are always a few up in the air and the sense of confidence in security has increased. In the IOC, SSgt Gladwine is monitoring the security dashboards when an alarm sounds. One of the gunshot audio detectors has alarmed near the south side of the base. Two of the drones immediately break off from patrol and head toward the detected gunshot. SSgt Gladwine clicks on the base alarm for an active shooter which initiates notification to all personnel on the base, the giant voice announces a lock down, everyone's smart device shows an alarm requesting confirmation for accountability, the gates have been closed and the first responders in the adjacent town have been notified. As the drones near the location of the detected sound, they easily find a hunter and send his picture back to the IOC, where the hunter's identity is verified through facial recognition. Security forces loads the clearly inebriated hunter into their patrol car so he can face the consequences.

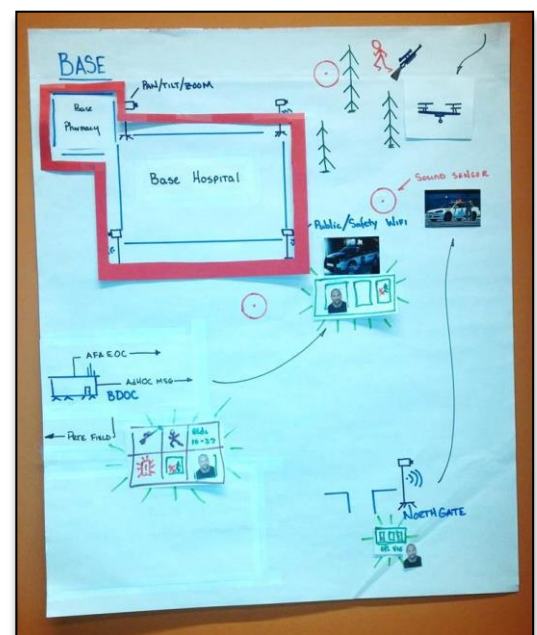


Figure 5: Crowd sourcing info from IoT devices enhances the base security by streamlining reporting and threat advisments.

Meanwhile, near one of the dorms, a self-described defender of justice, A1C Schmukatelli is studying the face of the shooter that came through in his smart watch hoping that he can find him and help security forces. With mixed emotions, he receives the all clear since the smart base tools enabled the very quick apprehension of the shooter by security forces.

Back in the clinic TSgt Lebowski is slightly embarrassed because when he tried to leave during the lockdown, his smart watch and smart phone both loudly reminded

him of the lockdown and he remembers that during these events AFGLIDE monitors locations for accountability and fences people into safe zones.

Not letting the embarrassment get him down, TSgt Lebowski gets to his office after the all clear. As he enters, the doors automatically unlocked due to the AFGLIDE sensors, the lights turn on, the AC adjusts to the occupied temperature and his computer is already logged in.

The thought of chili mac pops back into TSgt Lebowski's head, so he stops what he is doing and tells his smart watch to order the delivery service. With the self-driving delivery cars, he is glad that he can continue working through lunch. Just a few minutes after ordering his lunch, he gets an alert that the commander's official vehicle has just passed the threshold for an oil change. He flips through the commander's schedule and sets up the oil change. "Finally"....thinks TSgt Lebowski as he is notified that the food delivery has arrived. Stepping out to the parking lot, he sees that some of his peers from the maintenance shop had ordered their pickup for the same time and they discuss one of the interesting things they all heard on this morning's maintenance tips and tricks. Before going back to work, he sees that vehicle maintenance has arrived and the oil change is underway.

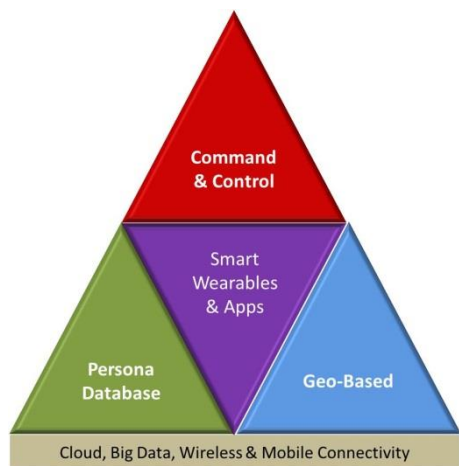


Figure 7: A bottom up approach allows IoT capabilities to be deployed when ready and as demanded rather than as one holistic requirement.

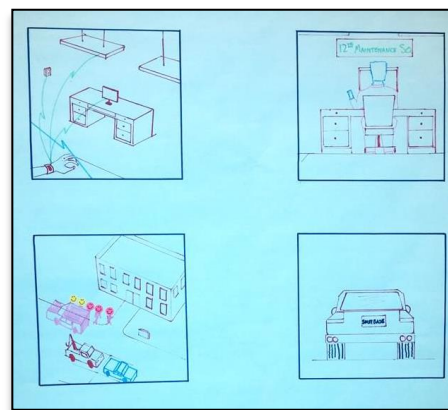


Figure 6: Wearables save time and money by setting up HVAC and lighting based on room occupancy and automating manual tasks for users such as logging in and ordering food.

It's late afternoon now and TSgt Lebowski is reminded that his daughter's karate tournament is coming up, but there is traffic along the way. He quickly says goodbye to his coworkers and as he leaves the office the lights turn off, the computer goes into sleep mode, the thermostat goes back to unoccupied mode and his door locks as he walks through.

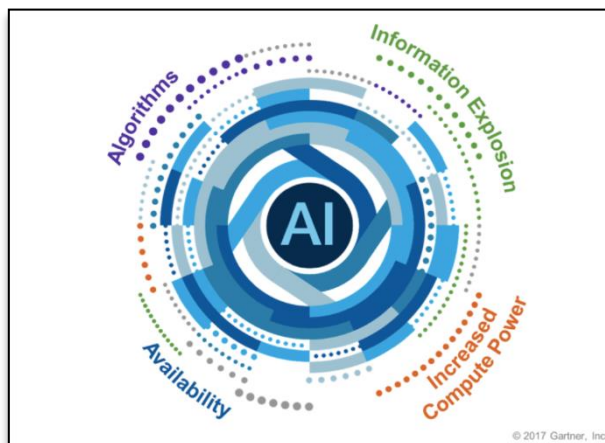
Meanwhile over in the IOC, SSgt Gladwine is glad that his duty day is nearly done. He really enjoys this time of the day watching the video feed of people leaving the gates and how the accountability dashboard automatically shows when AFGLIDE users leave for the day.

Recommendations and Next Steps

Though the story above may sound somewhat futuristic, the reality is that all the capabilities mentioned are in existence today. We recommend a bottom-up approach to implementation as depicted in in Figure 7.

A smart base architecture requires a foundation of cloud storage, big data, and wireless/mobile connectivity. The narrative highlights TSgt Lobowski's use of wearables and smart phone applications and demonstrates the benefits they provide as he goes about his day. Underpinning those technologies is the persona database and geo-location capability which provide context for the applications he relies on. This ecosystem of capabilities not only provides an improved experience for Airmen, it will also enable better command and control for base leaders and more efficient mission execution for the Air Force.

A ubiquitous, fully functional IoT infrastructure as described above is not without challenges. For most individuals two key objections immediately come to mind: privacy and security. Luckily the latter can be mitigated with proper security architecting. With regards to the former, places like Amazon, Facebook, and even grocery stores with their discount cards, have shown over and over again that individuals will sacrifice their individual privacy for value, convenience, and entertainment. By providing value to the base populous, they will likely opt-in to receiving this information in exchange for more efficient processes, and data points about their habits, which can be leveraged for continuous improvements.



Recommendations

1. Provide Valuable Information

Simple and easy access to information is something users take for granted these days. At home it is easy for airmen to get geo-located weather alerts, order food, get directions with contact information and operating hours to virtually any commercial establishment - all on their phone. With modern digital assistants the user need not even look at the screen – they simply ask.

During the design sprint one of the major complaints by airmen was a lack of easily accessible information. Airmen often couldn't get directions to base facilities (because we use building numbers rather than addresses) and were almost never able to easily find a facility's operating hours. The access problem gets worst when

you consider accessing information for base events and personnel information. AF processes seem to be reliant on email as the primary information dissemination method ignoring that fact that in every airman is carrying an information device and that virtually no one relies on email as a primary information tool anymore in their private lives. If not on email then base information is hidden in a myriad of web and SharePoint pages that users may not even know exist.

Luckily this is a problem that the AF can begin fixing easily and quickly – simply advertise base support and recreational facility operating hours on Google and Bing like every commercial organization does already. Consulting with a “search engine optimization” company will prove valuable. The development of AF mobile applications and true AF portal ecosystem that delivers relevant data to users based on desires, location and base operations.

2. Improve Coverage

Another aspect of smart bases that is both critical and relatively easily achieved is providing ubiquitous access to wifi and cellular service. Without decent access to these services delivery of and access to information as described above is not possible. Furthermore the AF should strive to provide both commercial and government wifi access with a goal of moving toward a bring your own device (BYOD) mentality to ensure better integration and access by each airman to public and private data from one device.



Figure 8: Making data accessible via centralized APIs or singular data stores will drive improved user tailoring and analytical efficiencies to base C2.

Improved coverage is critical not only for convenience: Airmen need saturated access drives and the ability to have instant SA and data coverage for base operations all across the installation. This will translate to more efficient operations of AF missions and more efficient time management by Airmen. The government need not provide all infrastructure—commercial partners (including those offering 5G internet) should be partners in the planning moving forward to acquisition.

3. Centralize Data

Facilitating access to data is a critical aspect of making it useable. As such we recommend creating a centralized data lake that mobile, web and C2 apps can access and report to. This will facilitate real-time data pushes and analytics of collected information to personalize each airmen’s experience and enhance C2 operations. Creating a data lake in no way implies that protected data types must be integrated, rather they all should be accessible with appropriate

controls via the same standards and APIs. The appointment of a Chief Data Officer for the AF may facilitate the transition toward such possibilities.

4. Leverage Data Analytics

Advanced analytics, data mining and machine learning algorithms, combined with centralized accessible data will spur cost savings, time savings, better situational awareness for individuals and operations, and quicker more informed decisions by commanders. Today algorithms drive much of our online and information experiences. Amazon recommends purchases and digital content based on a profile built by analyzing your prior activity and that of similar shoppers. The AF can leverage those data mining capabilities for everything from streamlining utility operations and lowering power costs at facilities, to providing behavioral predicates that collect sanitized user information to predict insider threats. Even simple tasks such as recalls and alert notifications could be streamlined with immediate accountability including location and time.

As you have read, the disruptive powers of the team's recommendations here are dependent on each being implemented. Each of these advancements must be done in order 1-4 or in parallel to fully realize the opportunities. The data and physical architecture CyberWorx contracted Gartner to develop should act as a guide of investment milestones to move the AF forward as quickly as resources allow.

Next Steps

1. Short term (immediate – 2 years):

- a. Publish facility information for support operations to standard web search engines. For example allow airmen to search for outdoor recreation in google maps to find directions, hours of operation and phone number.
- b. Provide a mobile friend website or application that allows airmen to receive information on base events, times and locations.
- c. Establish an architecture plan for ubiquitous access, IoT and data laking.
- d. Conduct follow on design sprints to articulate specific implementations and experimental cases.

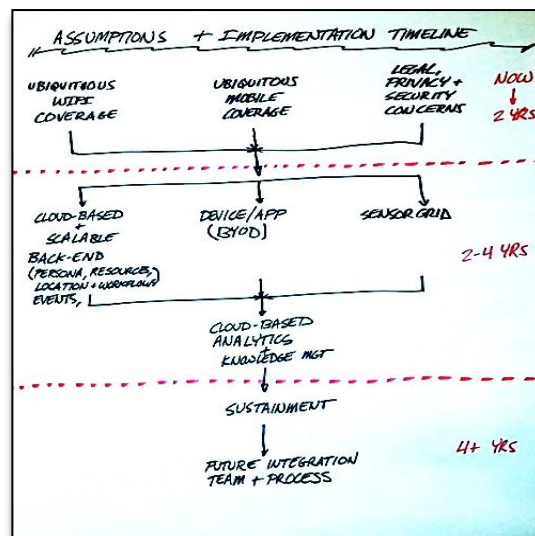


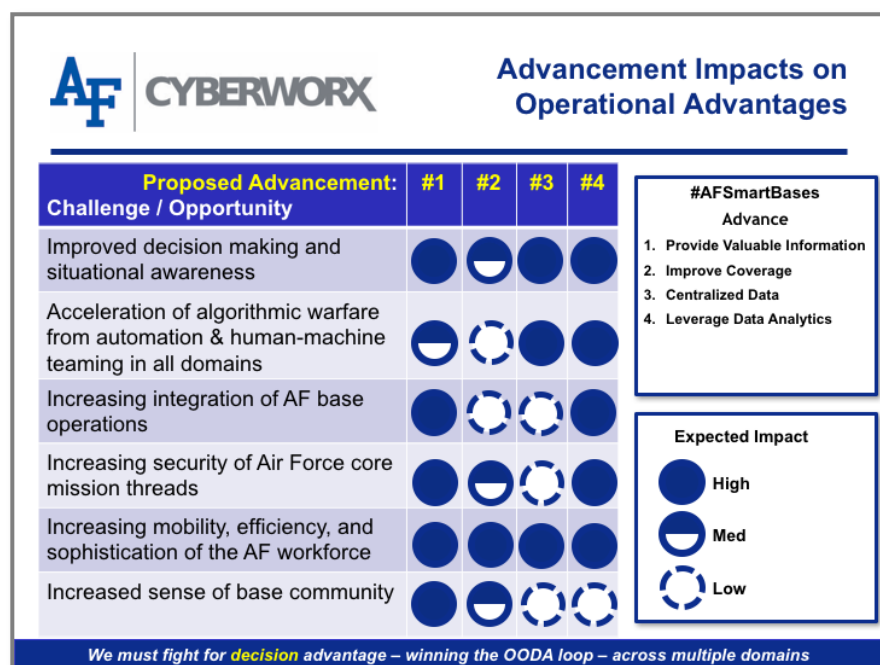
Figure 9: The design team's sketched way-ahead for smartbase implementation



- e. Begin implementation at USAFA and Maxwell as test beds to inform larger AF effort and make updates to the Air Force's & Functionals' IEMA roadmap.
2. **Intermediate term (2-4 years):**
 - a. Prioritize lessons from USAFA and Maxwell and implement at additional experimental bases.
 - b. Develop roadmap acquisition and security plan for enterprise deployment and continuous advancement of smart technologies via the IEMA roadmap.
 3. **Long term (4+ years):**
 - a. Deploy most successful technologies to AF- & DoD-wide.

Summary: Ops Advantages + Fast Track

The CyberWorx “three slide summary” section is designed to help you consider the recommendations in this report by weighing the operational improvements proposed against the current cyber challenges and opportunities we face as an Air Force.

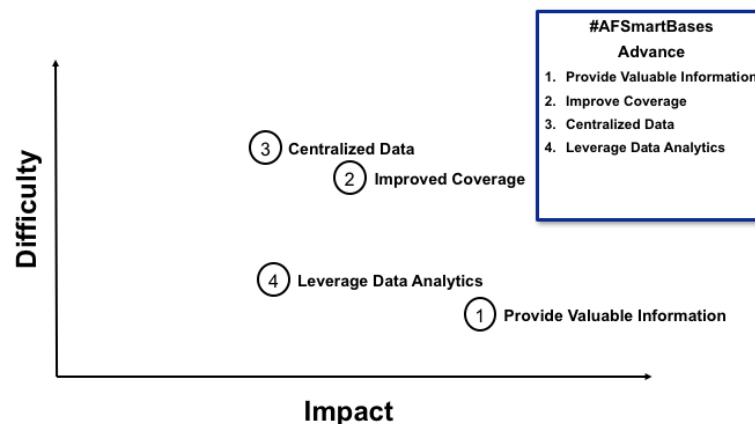


In deciding what to do, the decision to do nothing is a decision and brings its own risks. Thus, the “fast track” slide spells out an easy set of actions to take at minimum to start trying to improve and to put the Air Force on a path of discovery in overcoming the challenges that drove this design project.

- **Leverage industry better**
 - Activity hours on Google & Bing
 - Search Engine Optimization (SEO)
 - Ubiquitous Wi-Fi/Cellular/5G
 - Gartner design enabling data arch
- **Prioritize capes, adjust arch to enable additional pilots**
- **Translate Gartner-to-IEMA roadmap & acquisition plan for implementing designed smart-base solution**
- **Conduct follow-on experimentations at bases, enabling Airmen to improve their lives and squadron operations**
 - Fall 17 project w/ CyberWorx for further refinement, development and prototyping for USAFA (stress-test architecture)
 - Maxwell AFB using a CRADA to experiment with integration of specific vendor capabilities into operations



We recognize we live in a resource-constrained world. Each advance proposed in this report is graphed below: The graph compares the advance's relative impact on the ability of the Air Force to maintain information and decision dominance (x-axis) against the difficulty (e.g., expenditure of time/treasure, cultural evolution, policy change) needed to implement that advance (y-axis). Cultural changes, like some of those proposed in this report, are not easy, but they are possible and needed for success in our digital, cyber-contested world.



Note: This project was the first CyberWorx project in which a follow-on product was contracted (from Gartner, Inc.) as part of the deliverable. The intent was to provide a view of the architecture needed for the Air Force to move forward. The view was to be based on redesigning the architecture of USAFA and Maxwell AFB, as these are two bases at which the Air Force can take healthy risks. The intent is to learn from these two bases and scale what works for additional bases and missions toward an enterprise solution for incorporating smart technologies in the future (defined in the Information Environment Mission Area, IEMA, roadmap and by multiple functional communities). That contracted way-forward should accompany this report for some readers: it is not publically releasable, however, at least at the time of this report writing, because of the way the contract was written.

This report & accompanying architecture represents the designed way forward for smart Air Force installations and provides a glide path to allow industry to implement designed solutions enterprise-wide. The user stories, personas, and accompanying presentations and vignettes may be infinitely expandable and applicable to what is possible for Airmen fighting in the digital age—we are limited in our innovations only by our imagination and where we decide to apply resources.

